

NuScaleDCRaisPEm Resource

From: Chowdhury, Prosanta
Sent: Wednesday, March 21, 2018 2:34 PM
To: Request for Additional Information
Cc: Lee, Samuel; Cranston, Gregory; Franovich, Rani; Bovol, Bruce; Karas, Rebecca; Burja, Alexandra; NuScaleDCRaisPEm Resource
Subject: Request for Additional Information No. 394 eRAI No. 9401 (15.02.01-15.02.05)
Attachments: Request for Additional Information No. 394 (eRAI No. 9407).pdf

Attached please find NRC staff's request for additional information (RAI) concerning review of the NuScale Design Certification Application.

Please submit your technically correct and complete response within 60 days of the date of this RAI to the NRC Document Control Desk.

If you have any questions, please contact me.

Thank you.

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Request for Additional Information No. 394 (eRAI No. 9407)

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Application Title: NuScale Standard Design Certification - 52-048

Operating Company: NuScale Power, LLC

Docket No. 52-048

Review Section: 15.02.01-15.02.05 - Loss of External Load; Turbine Trip; Loss of Condenser Vacuum; Closure of Main Steam Isolation Valve (BWR); and Steam Pressure Regulator Failure (Closed)

Application Section:

QUESTIONS

15.02.01-1

The transient and accident analyses in FSAR Tier 2, Chapter 15 serve, in part, to demonstrate compliance with the general design criteria (GDC) in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix A. Design-Specific Review Standard (DSRS) Section 15.2.1-15.2.5, "Loss of External Load; Turbine Trip; Loss of Condenser Vacuum; Closure of Main Steam Isolation Valve; and Steam Pressure Regulator Failure (Closed)," provides guidance for meeting the requirements of GDC 10, "Reactor design"; 13, "Instrumentation and control"; 15, "Reactor coolant system design"; 17, "Electric power systems"; and 26, "Reactivity control system redundancy and capability." To meet these requirements, DSRS Section 15.2.1-15.2.5 states that one of the basic objectives of the review of the initiating events covered under the DSRS section is to identify which moderate-frequency event that results in an unplanned decrease in secondary system heat removal is the most limiting. Furthermore, DSRS Section 15.2.1-15.2.5 guides the reviewer to evaluate the applicant's justification if the applicant's technical submittal states that one of these transients is not as limiting as other similar transients.

FSAR Tier 2, Sections 15.2.1 through 15.2.3 describe the loss of external load (LOEL), turbine trip (TT), and loss of condenser vacuum (LOCV) events and include a single evaluation for all three events, presumably because FSAR Section 15.2 states that these events produced essentially identical responses for the acceptance criteria (reactor coolant system [RCS] pressure, steam generator [SG] pressure, and minimum critical heat flux ratio [MCHFR]). FSAR Sections 15.2.1 through 15.2.3 do not indicate which event (LOEL, TT, or LOCV) is most limiting for each acceptance criterion. The staff notes that phenomenological differences between the LOEL, TT, and LOCV events lead to some differences in the event timing and severity. For example, the staff would expect that the immediate loss of feedwater that occurs with a LOCV would cause a higher and faster peak RCS pressure than the LOEL and TT events.

For consistency with DSRS Section 15.2.1-15.2.5, and to enable the staff to conclude based upon docketed material that the most limiting cases have been accurately identified, please update the FSAR to indicate the events (LOEL, TT, or LOCV) that led to the limiting analysis sequences of events and results in FSAR Tier 2, Tables 15.2-4 through 15.2-7.

15.02.01-2

The transient and accident analyses in FSAR Tier 2, Chapter 15 serve, in part, to demonstrate compliance with the GDC. DSRS Section 15.2.1-15.2.5 provides guidance for meeting the requirements of GDC 10, 13, 15, 17, and 26, and in doing so, guides the staff to review the extent

to which credit is taken for the functioning of normally operating plant systems. Performance of non-safety-related systems during transients and accidents and single failures of active and passive systems (especially as to the performance of check valves in passive systems) must be evaluated and verified according to the guidance of SECY 77-439, SECY 94-084, and RG 1.206.

FSAR Tier 2, Section 15.2.1, "Loss of External Load," states that plant control systems perform as designed with allowances for instrument inaccuracy unless stated otherwise. FSAR Tier 2, Section 15.2.1 describes that the turbine bypass system is assumed not to perform as designed; however, there is no other discussion of credit for plant control systems (PCSs) for the LOEL, TT, and LOCV events. The staff would expect similar assumptions to be made for these events as are described in FSAR Section 15.2.4, "Closure of Main Steam Isolation Valve(s)," which discusses the functionality of the chemical and volume control system and pressurizer spray system. Please confirm whether any other non-safety-related PCSs, such as the pressurizer pressure or level control functions of the module control system, are assumed to operate during the LOEL, TT, and LOCV transients. Update the FSAR as appropriate.

15.02.01-3

The transient and accident analyses in FSAR Tier 2, Chapter 15 serve, in part, to demonstrate compliance with the GDC. DSRS Section 15.2.1-15.2.5 provides guidance for meeting the requirements of GDC 10, 13, 15, 17, and 26. To meet these requirements, DSRS Section 15.2.1-15.2.5 states that the most limiting plant system single failure, as defined in the "Definitions and Explanations" of 10 CFR Part 50, Appendix A, must be assumed in the analysis and must satisfy the positions of RG 1.53, "Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems."

FSAR Tier 2, Section 15.2.1 states that "no single failure resulted in a more limiting RCS pressure." Based on its audit of EC-0000-1997, Revision 0, "Loss of External Load, Turbine Trip, Loss of Condenser Vacuum," and ECN-0000-4862, "Loss of External Load, Turbine Trip, Loss of Condenser Vacuum – Impact Analysis" (which are the calculations of record for the analyses presented in FSAR Sections 15.2.1, 15.2.2, and 15.2.3), the staff notes that single failures were not examined for the LOEL cases because of their similarity to TT cases, which did examine single failures. The staff further notes that a failure of a feedwater isolation valve (FWIV) to close for a TT event was slightly more limiting than assuming no single failure. The same is true for the LOCV event. Because the peak RCS pressure case for the LOEL, TT, and LOCV events assumes a failure of a FWIV, the FSAR should reflect that assumption. Please update the FSAR as appropriate.

15.02.01-4

The transient and accident analyses in FSAR Tier 2, Chapter 15 serve, in part, to demonstrate compliance with the GDC. DSRS Section 15.2.1-15.2.5 provides guidance for meeting the requirements of GDC 10, 13, 15, 17, and 26, and guides the staff to review the extent to which plant and reactor protection systems are required to function.

FSAR Tier 2, Section 15.2.1 states that the RCS pressure does not reach the reactor safety valve (RSV) actuation setpoint for the limiting MCHFR case for the LOEL event. This appears to be true for LOEL based on a staff audit of EC-0000-1997, Revision 0. FSAR Tier 2, Sections 15.2.2 and 15.2.3 state that the events proceed the same as in Section 15.2.1, thus implying that RCS pressure does not reach the RSV actuation setpoint. However, the staff notes that

EC-0000-1997 shows that the RSV does actuate for the overall limiting MCHFR event for LOEL, TT, and LOCV.

Therefore, please update the FSAR to state that the RSV actuates for the limiting MCHFR event.

15.02.01-5

The transient and accident analyses in FSAR Tier 2, Chapter 15 serve, in part, to demonstrate compliance with the GDC. DSRs Section 15.2.1-15.2.5 provides guidance for meeting the requirements of GDC 10, 13, 15, 17, and 26, and guides the reviewer to evaluate the values of system parameters and initial core and system conditions as input to the model.

For the LOEL/TT/LOCV events, the staff notes that FSAR Tier 2, Table 15.2-1 does not list the steam generator heat transfer bias for the peak RCS pressure case, and FSAR Tier 2, Table 15.2-2 does not list the initial pressurizer pressure assumed for the peak SG pressure case. To enable the staff to make a finding with regard to the choice of initial system conditions, please update the FSAR to include the values for these biases.

In addition, the staff would expect biased-low SG heat transfer to reduce heat removal from the RCS and potentially be more challenging for RCS pressure and/or MCHFR. However, FSAR Tier 2, Table 15.2-3 indicates that biased-high SG heat transfer is limiting for MCHFR, and based on the staff audit of EC-0000-1997, a nominal value is used for peak RCS pressure. Explain why biased-low SG heat transfer is not limiting for these cases. Update the FSAR as appropriate.

15.02.01-6

The transient and accident analyses in FSAR Tier 2, Chapter 15 serve, in part, to demonstrate compliance with the GDC. DSRs Section 15.2.1-15.2.5 provides guidance for meeting the requirements of GDC 10, 13, 15, 17, and 26, and specifies that the applicant should analyze the events using an acceptable analytical model.

In auditing ECN-0000-4862 and EC-A010-1782, "NuScale NRELAP5 Module Basemodel" (the base analysis model used for the FSAR Chapter 15 analyses), the staff noted that the heat transfer option used to model heat transfer between the DHRS and the pool in the NRELAP5 basemodel and the LOEL, TT, and LOCV events appears to be different from what is stated to be used in TR-0516-49416-P, "Non-Loss-of-Coolant Accident Analysis Methodology," which is referenced in FSAR Chapter 15 as the evaluation model used for non-LOCA events. Please justify the differences in methodology between ECN-0000-4862/EC-A010-1782 and TR-0516-49416-P, and also clarify and justify the heat transfer option used for all other FSAR Chapter 15 analyses. Update the FSAR as appropriate.

15.02.01-7

The transient and accident analyses in FSAR Tier 2, Chapter 15 serve, in part, to demonstrate compliance with the GDC. DSRs Section 15.2.1-15.2.5 provides guidance for meeting the requirements of GDC 10, 13, 15, 17, and 26, and guides the reviewer to review, among other things, the sequence of events.

FSAR Tier 2, Tables 15.2-4 through 15.2-6 intend to provide the limiting sequence of events with respect to RCS maximum pressure, SG maximum pressure, and MCHFR for the LOEL, TT, and LOCV events. The staff notes that Tables 15.2-4 through 15.2-6 do not appear to be consistent with the sequence of events tables the staff audited in ECN-0000-4862, provided via EC-0000-1997, Revision 0. For example, Table 15.2-5 shows that the reactor trip and DHRS actuation analytical limit is reached at 5 seconds, and the trip and DHRS actuation occur at 7 seconds. However, ECN-0000-4862 shows these events occur at 7 and 9 seconds, respectively. Table 15.2-5 also shows that the RSV lift setpoint is reached for the SG pressure limiting case at 9 seconds, but both ECN-0000-4862 and FSAR Section 15.2.1.2 state that the RSV lift setpoint is not reached at all for the SG pressure case. Furthermore, based on Tables 15.2-4 through 15.2-6, the decay heat removal system (DHRS) valves fully open before the 30 second delay following DHRS actuation, which is not consistent with the analysis assumptions in EC-0000-1997 or the design basis description of the valves in FSAR Section 5.4.3.2.1, which states that the DHRS actuation valves are designed to fully open within 30 seconds from receipt of a DHRS actuation signal.

The limiting sequences of events should be accurately identified so the staff is able to assess the event response. Please identify whether any errors exist in Tables 15.2-4 through 15.2-6. If errors are present, update the FSAR as appropriate. If no errors are present, explain the apparent lack of consistency between the FSAR and ECN-0000-4862.

15.02.01-8

The transient and accident analyses in FSAR Tier 2, Chapter 15 serve, in part, to demonstrate compliance with GDC 15. GDC 15 requires that the reactor coolant system (RCS) and associated auxiliary, control, and protection systems shall be designed with sufficient margin to assure that the design conditions of the reactor coolant pressure boundary are not exceeded during any condition of normal operation, including anticipated operational occurrences. DSRS Section 15.2.1-15.2.5 provides guidance for meeting the requirements of several GDC, including GDC 15, and specifies that pressure in the reactor coolant and main steam systems should be maintained below 110 percent of the design values.

The staff notes that FSAR Figure 15.2-7 shows pressurizer pressure for the LOEL, TT, and LOCV maximum RCS pressure case, but the peak pressure shown in the figure is less than the maximum RCS pressure in FSAR Table 15.2-7 (2158 psia), presumably because the maximum RCS pressure occurs at a different location in the RCS. To allow the staff to verify the RCS pressure response for these events, please provide and add to the FSAR a new figure that shows the pressure response for the location of maximum RCS pressure for the LOEL, TT, and LOCV events.

15.02.01-9

The transient and accident analyses in FSAR Tier 2, Chapter 15 serve, in part, to demonstrate compliance with the GDC. GDC 10 requires that the reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that specified acceptable fuel design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences. DSRS Section 15.2.1-15.2.5 provides guidance for meeting the requirements of several GDC, including GDC 10, and specifies that the minimum departure from nucleate boiling ratio (DNBR) must remain above the

95/95 DNBR limit based on acceptable correlations and by satisfaction of any other SAFDL applicable to the particular reactor design. In this case, the SAFDL is MCHFR.

The timing of MCHFR in FSAR Tier 2, Figure 15.2-9, "Hot Channel Node MCHFR – Limiting MCHFR Case (15.2.1-15.2.3 LOEL-TT-LOCV)," is not consistent with the sequence of events in Table 15.2-6 (specifically, Figure 15.2-9 indicates that MCHFR occurs at about 13 seconds, while Table 15.2-6 states 16 seconds). The staff also notes that FSAR Tier 2, Figure 15.2-18, "Minimum Critical Heat Flux Ratio – Limiting MCHFR Case (15.2.4 MSIV Closure)," shows MCHFR at about 7 seconds, while FSAR Tier 2, Table 15.2-13, "Main Steam Isolation Valve Closure - Sequence of Events for MCHFR Limiting Case," reports 8 seconds.

Please update Figures 15.2-9 and 15.2-18 and/or Tables 15.2-6 and 15.2-13 as appropriate so the staff can be sure the correct MCHFR timing is plotted. In addition, correct any other MCHFR sequence of events tables and/or figures presented in FSAR Chapter 15 as necessary to reflect the correct timing of MCHFR.

15.02.01-10

The transient and accident analyses in FSAR Tier 2, Chapter 15 serve, in part, to demonstrate compliance with the GDC. DSRs Section 15.2.1-15.2.5 provides guidance for meeting the requirements of GDC 10, 13, 15, 17, and 26. To meet these requirements, DSRs Section 15.2.1-15.2.5 states that the most limiting plant system single failure, as defined in the "Definitions and Explanations" of 10 CFR Part 50, Appendix A, must be assumed in the analysis and must satisfy the positions of RG 1.53, "Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems."

FSAR Tier 2, Section 15.2.4, "Closure of Main Steam Isolation Valve(s)," states that no single failure results in more severe results for any of the acceptance criteria. However, the staff notes that a failure of the feedwater isolation valve (FWIV) to close is limiting for SG pressure in FSAR Tier 2, Sections 15.2.1-15.2.3 for the LOEL, TT, and LOCV events because of the additional feedwater provided to the SG. Justify why failure of a FWIV to close is not limiting for SG pressure for the MSIV closure event. Update the FSAR as appropriate.

15.02.01-11

The transient and accident analyses in FSAR Tier 2, Chapter 15 serve, in part, to demonstrate compliance with the GDC. DSRs Section 15.2.1-15.2.5 provides guidance for meeting the requirements of GDC 10, 13, 15, 17, and 26, and guides the reviewer to evaluate the values of system parameters and initial core and system conditions as input to the model. Several of the initial conditions selected for the MSIV closure event in FSAR Tier 2, Section 15.2.4 are not clear, because they either appear inconsistent with conclusions that can be drawn from the sensitivity studies in EC-0000-2995, Rev. 1, "Closure of Main Steam Isolation Valve Transient Analysis," or they deviate from the phenomenologically similar LOEL, TT, and LOCV event bias directions. Please explain the following points, and provide any updates to the FSAR as necessary:

- FSAR Tier 2, Table 15.2-8 lists initial conditions for the limiting RCS pressure case. The staff notes that the initial RCS average temperature (T_{ave}) is biased high, whereas the MSIV closure sensitivity studies and LOEL, TT, and LOCV analysis both seem to suggest a biased-low RCS T_{ave} is limiting for RCS peak pressure.

- Table 15.2-8 also shows a low SG pressure bias, whereas the LOEL, TT, and LOCV analysis used a high SG pressure bias.
- FSAR Tier 2, Table 15.2-9 lists initial conditions for the limiting SG pressure case. The initial pressurizer level and SG pressure are both biased low, whereas they are both biased high for the LOEL, TT, and LOCV analysis.
- FSAR Tier 2, Table 15.2-10 lists initial conditions for the MCHFR limiting case. The initial pressurizer pressure is biased high, although the MSIV closure sensitivity studies and the LOEL, TT, and LOCV analysis both suggest a low bias may be limiting.

Furthermore, FSAR Tier 2, Tables 15.2-8 and 15.2-9 for the MSIV closure event do not list the assumed RCS flow. Please update the tables to include the initial RCS flow.

15.02.01-12

The transient and accident analyses in FSAR Tier 2, Chapter 15 serve, in part, to demonstrate compliance with the GDC. Per DSRs Section 15.2.1-15.2.5, the information in the related FSAR sections is reviewed against GDC 10, 13, 15, 17, and 26. The information in the FSAR that supports meeting these regulations needs to be accurate and consistent so the staff is able to make a reasonable assurance finding.

The staff noted that FSAR Tier 2, Sections 15.2.1-15.2.5 and the related tables and figures contain apparent typographical errors that affect technical meaning or details. These errors are listed below:

- FSAR Section 15.2.1.3.3, "Results," refers to limiting MCHFR in Figure 5.2-9, but the correct figure number is 15.2-9.
- FSAR Sections 15.2.2.2 and 15.2.3.2, both titled "Sequence of Events and System Operation," refer to more than one turbine stop valve (TSV). However, the staff notes that FSAR Chapter 10 indicates there is only one TSV per NPM.
- The title of Table 15.2-3 indicates it is a sequence of events table, but it is actually an initial conditions table.
- FSAR Tier 2, Figure 15.2-12 is titled "Net Reactivity – Peak RCS Pressure Case (15.2.4 MSIV Closure)" but appears to show RCS flow rate instead.

Please address the above items by (1) justifying why they are correct as written or (2) by updating FSAR Tier 2 to correct them.